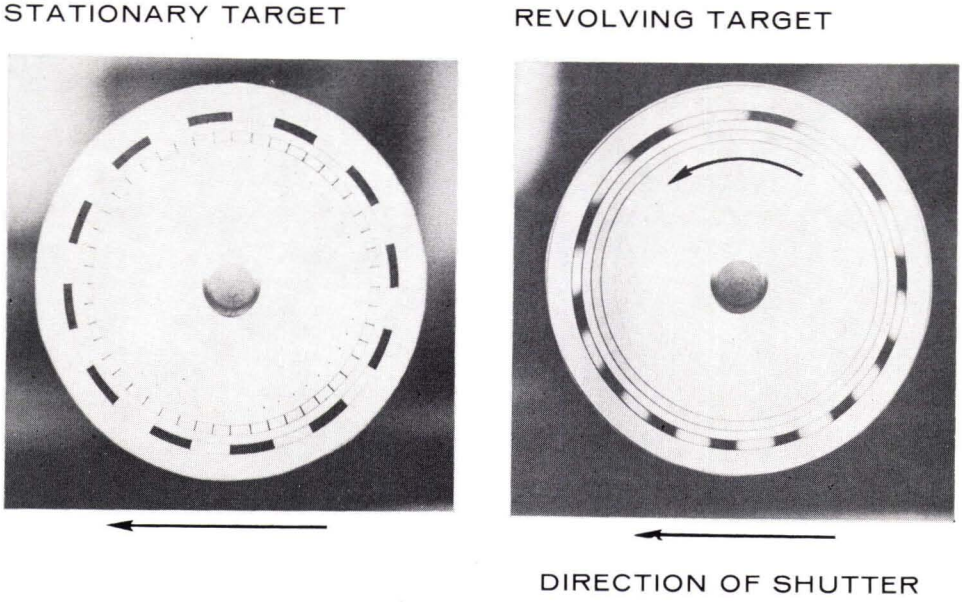

FIG. 1. Image distortion resulting from photographing a moving subject with a focal plane shutter.

Photogrammetric Brief

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Distortions by Focal Plane Shutters

RECONNAISSANCE CAMERAS have been relied upon for large-scale aerial photography at scale of 1:1,000 to 1:2,000 because they have the rapid film cycling capability required for obtaining sufficient stereo overlap and the fast shutter speeds needed to ensure sharp images. Generally these cameras have a 70 mm. format and use focal plane shutters.

Excellent quality large-scale photographs can be taken with such cameras and, though the photographs are intended mainly for qualitative information, accurate quantitative information can also be obtained. For example, precise measurements of trees for timber assessment purposes are feasible, and methods for implementing this application are now being developed (Sayn-Wittgenstein and Aldred, 1967).

Caution should be exercised in the use of photo measurements derived from reconnaissance photographs. Schut and van Wijk (1965) pointed out that the lenses, lens alignment, film flatness, and other geometric characteristics of the camera do not always meet the high standards of precision required in cartographic cameras. This lack certainly does not preclude accurate measurements on reconnaissance photographs but the user should recognize their limitations.

One source of distortion that should not be overlooked results from the use of focal plane shutters. It becomes particularly significant in large-scale photography. Though the focal plane shutter may give an extremely fast exposure, such as 1/1,000th of a second, the exposure slit takes a longer time to pass across the frame. During this interval the camera

movement, as occurs in aerial photography, or subject movement (Figure 1) results in distortions. For example, the image of the revolving target in Figure 1 is elongated where the target moves in the same direction as the shutter blind and shortened where the target moves in the opposite direction. In aerial photography, the distance travelled by the aircraft in the time taken for the exposure slit to pass from one side of the frame to the other results in similar distortions.

If Vinten 70-mm. focal-plane photography is selected as an example, and if the aircraft speed is assumed to be 120 miles per hour (53.64 meters per second), the shutter blind slit 3 mm. wide, and the length of exposure 1/1,000th of a second, the distortion can be postulated as follows. The shutter travels 3 mm. in 1/1,000th of a second and therefore takes $(70/3) \times 0.001 = 0.0233$ seconds to travel the width of the 70 mm. frame. For an aircraft travelling at 53.64 meters per second, the distance travelled over the ground (and resulting in a distortion) while the slit was moving across the frame, would be $0.0233 \times 53.64 = 1.25$ meters.

This postulation was borne out in an experiment. A group of evenly spaced targets was photographed from the air so that one set was aligned parallel to the exposure slit and the other set perpendicular to the slit. Scale was determined from measured distances between the targets on the ground and on the photos. Photo distances measured between targets lying parallel to the slit should not have been distorted because the targets would have been exposed at the same time. These measurements were used as a standard against which measurements made perpendicular to the slit could be compared.

In the test, measurements made on the negatives of targets lying parallel to the exposure slit gave a scale of 1:1,723.5; measurements made in the perpendicular direction gave a scale of 1:1,705.1. Across a 70-mm. frame this would represent a distortion of 1.29 meters, which is close to the predicted distortion.

The user of large-scale aerial photographs should not ignore the scale distortion that can be caused by focal plane shutters. A slower aircraft or a faster moving shutter blind will reduce the distortion. Photo measurements can be corrected for this distortion.

References

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Schut, G. H. and van Wijk, M. C., "The determination of tree heights from parallax measurements," *The Canadian Surveyor*, Vol. 19, No. 5, Dec. 1965, pp. 415–427.